(12) UK Patent Application (19) GB (11) 2 238 745 (13) A

(43) Date of A publication 12.06.1991

(21) Application No 9019766.6

(22) Date of filing 10.09.1990

(30) Priority data
(31) 01234032 (32) 09.09.1989 (33) JP

(71) Applicant
Brother Kogyo Kabushiki Kaisha

(Incorporated in Japan)

9-35 Horita-dori, Mizuho-ku, Nagoya 467, Japan

(72) Inventors
Fumio Kameyama
Chikamasa Hattori

(74) Agent and/or Address for Service
J A Kemp and Co
14 South Square, Gray's Inn, London, WC1R 5LX,
United Kingdom

(51) INT CL[5]
B23G 1/18, B23B 47/02, B23Q 5/10

(52) UK CL (Edition K)
B3N N2C3 N2E1 N3D3
B3B B3B2

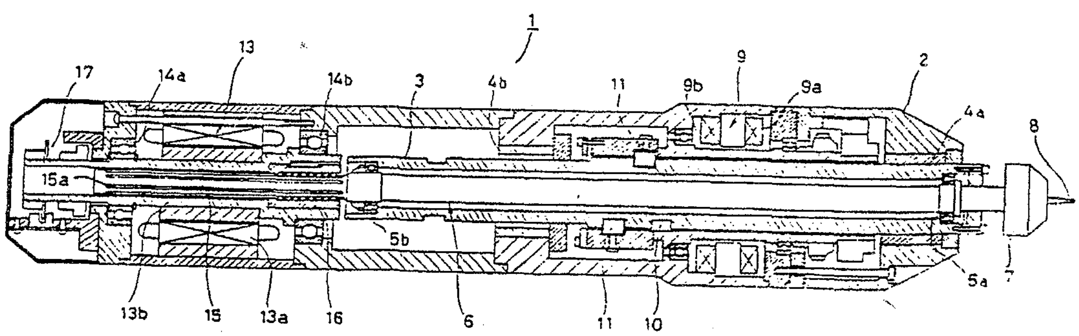
(56) Documents cited
WO 88/00507 A1

(58) Field of search
UK CL (Edition K) B3B, B3C, B3N
INT CL[5] B23B, B23G, B23Q

(54) Power tool

(57) The tool has a spindle 6 carrying a tap 8 mounted for axial movement in a housing 2, a servo motor 9 for moving the spindle 6 in the axial direction and a variable reluctance motor 13 for rotating the spindle. A synchronous controller for synchronizing and driving the servo motor 9 and the variable reluctance motor 13 is provided. By using a variable reluctance motor to rotate the spindle, it is possible to obtain a large torque without needing a large motor. A drill may be used instead of the tap 8.

FIG. 1



Spindle

GB 2 238 745 A

FIG. 1

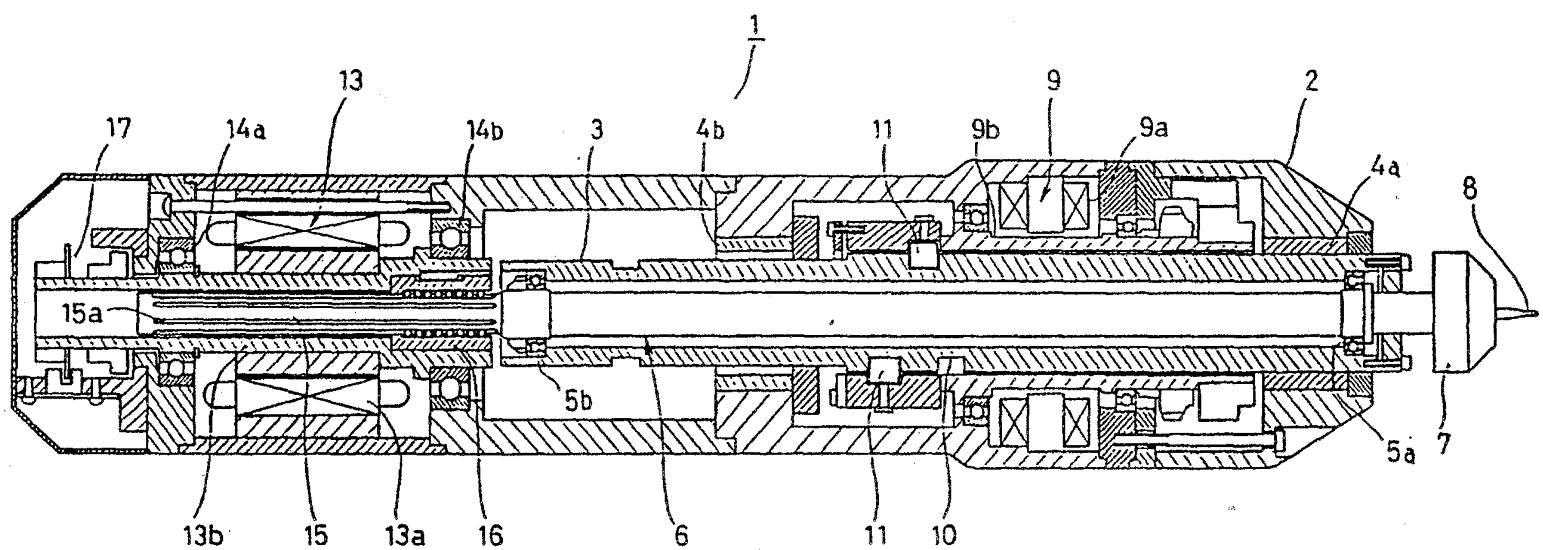


FIG. 2

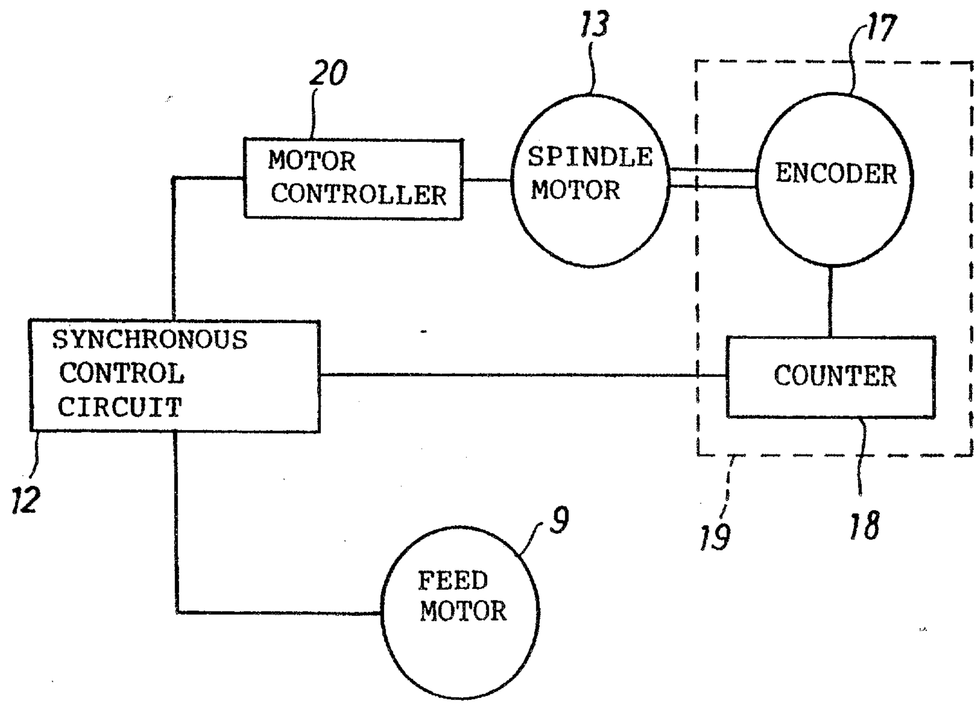
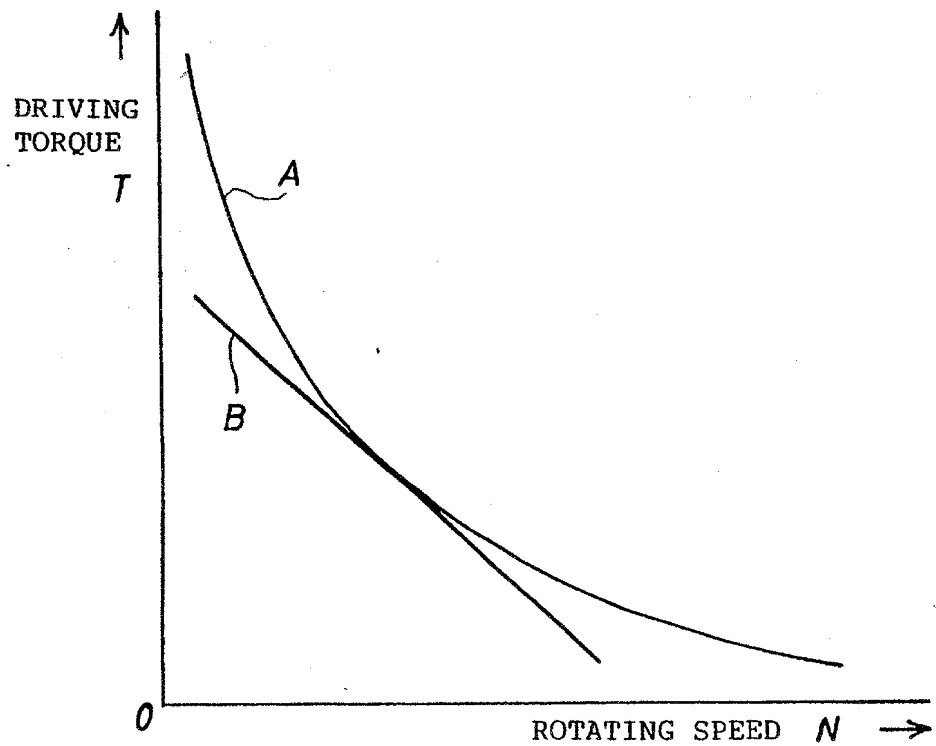

MOTOR CONTROLLER
20
SPINDLE MOTOR
13
ENCODER
17
COUNTER
18
19
SYNCHRONOUS CONTROL CIRCUIT
12
FEED MOTOR
9

FIG. 3



A MACHINE TOOL

This invention relates to a device for machining a workpiece that machines using tools, such as taps and drills, which reciprocate in an axial direction while rotating about their axes.

One example of this type of device is a tapping unit for tapping a workpiece. This machine has a spindle which is rotatably provided around an axis in a housing. The spindle is reciprocated in the axial direction by a feed motor and also rotated at a low speed by a spindle motor. The spindle is equipped with a tap at its end portion to apply tapping to a workpiece. Generally, a DC motor or an AC inductive motor has been used as the above-mentioned spindle motor.

Concerning the above-mentioned tapping unit, miniaturization and weight reduction is desirable. However, it is also desired that even a small-type tapping unit be able to tap a large-diameter workpiece. If a DC motor is adopted as the above-mentioned spindle motor, a large size spindle motor is required to obtain sufficient torque to tap a large-diameter workpiece. Consequently the unit becomes a large system. Moreover, since the use of a DC motor using permanent magnets involves a problem of demagnetization, it is difficult to provide a large current to get a large driving torque. On the other hand, if an AC inductive motor is used, it is hard to obtain a high torque. It is, therefore, necessary to use a

large size motor or reduce the speed of the motor by a reduction gear. As a result, the unit becomes a large scale unit or the revolution speed is reduced.

An object of the present invention is to provide a device which is able to produce a high torque and machine large-diameter workpieces without being excessively large.

According to one aspect of the present invention there is provided a device for machining a work piece, comprising:

a housing;

a spindle supported within the housing and defining a longitudinal axis such that the spindle is rotatable about and reciprocatable along that axis, the spindle being adapted to receive a tool at one end;

a feed motor mounted in the housing for reciprocating the spindle along the spindle axis;

a variable reluctance motor mounted in the housing for rotating the spindle about the spindle axis; and

control means for simultaneously controlling the feed motor and variable reluctance motor.

According to a second aspect of the present invention there is provided a device for machining a work piece, comprising:

a cylindrically shaped housing;

a spindle sleeve coaxially mounted within the housing such that the spindle sleeve may reciprocate along and rotate about an axis, a spiral cam groove being formed on the outer surface of the spindle sleeve;

a spindle having a first end coaxially mounted within the spindle sleeve such that the spindle may rotate about the axis relative to the spindle sleeve and reciprocate along the axis with the spindle sleeve, splines being formed on the first end of the spindle, the second end of the spindle being adapted to receive a tool;

a feed motor installed in the housing for

reciprocating the spindle along the axis, the feed motor comprising:

a feed motor stator attached to the inside of the housing,

a feed motor rotor rotatably mounted adjacent the feed motor stator and comprising a hold in which the spindle sleeve is mounted, and

cam followers mounted on the surface of the hole in the feed motor rotor adapted to engage the cam groove such that, when the rotor rotates, the cam followers act on the cam groove to reciprocate the spindle sleeve and spindle along the axis;

a variable reluctance motor installed in the housing for rotating the spindle about the axis, the variable reluctance motor comprising

a reluctance motor stator attached to the inside of the housing;

a reluctance motor rotor rotatably mounted adjacent the reluctance motor stator, splines being formed on the reluctance motor parallel to the axis for engaging the splines formed in the first end of the spindle such that rotation of the reluctance motor rotor causes the spindle to rotate about the axis while allowing the spindle to reciprocate along the axis; and

control means for substantially simultaneously controlling the feed motor and variable reluctance motor.

According to a third aspect of the invention there is provided device for machining a work piece, comprising:

a cylindrically shaped housing;

a spindle sleeve coaxially mounted within the housing such that the spindle sleeve may reciprocate along and rotate about an axis, a spiral cam groove being formed on the outer surface of the spindle sleeve;

a spindle having a first end coaxially mounted within the spindle sleeve such that the spindle may rotate

about the axis relative to the spindle sleeve and reciprocate along the axis, where splines are formed on the first end of the spindle, the second end of the spindle being adapted to receive a tool;

a feed motor installed in the housing for reciprocating the spindle along the axis, the feed motor comprising

a feed motor stator attached to the inside of the housing;

a feed motor rotor rotatably mounted adjacent the feed motor stator and comprising a hole in which the spindle sleeve is mounted, and

cam followers mounted on the surface of the hole in the feed motor rotor for engaging the cam groove such that, when the feed motor rotor rotates, the cam followers act on the cam groove to reciprocate the spindle sleeve and spindle along the axis,

a variable reluctance motor installed in the housing for rotating the spindle about the axis, the variable reluctance motor comprising:

a variable reluctance motor stator attached to the inside of the housing;

a variable reluctance motor rotor rotatably mounted adjacent the reluctance motor stator, where splines are formed on the reluctance motor rotor parallel to the axis and adapted to engage the splines formed on the first end of the spindle such that the rotation of the reluctance motor rotor causes the spindle to rotate about the axis while allowing the spindle to reciprocate along the axis;

control means for controlling the feed motor and variable reluctance motor; and

rotation speed detecting means for detecting a rotation speed of the spindle;

the control means being adapted to substantially simultaneously control the feed motor to move the spindle

at a reciprocation speed in accordance with the rotation speed.

The servo motor for moving a spindle in the axial direction and a variable reluctance motor for rotating the spindle of the present invention may be installed in a small housing, and they may be synchronized and actuated simultaneously by the control means.

The invention will be better understood from the following description, when taken with the attached drawings, which are given by way of illustration only and in which:-

Fig. 1 is a longitudinal sectional view of a device according to the present invention.

Fig. 2 is a block diagram showing an electrical constitution of the present embodiment.

Fig. 3 is a characteristic diagram showing the relation between the driving torque and the rotating speed of a variable reluctance motor and a DC motor.

Fig. 1 shows the whole constitution of a tapping unit 1 as a machine tool of the present invention. In a housing 2 which has an almost cylindrical shape as a whole, a cylindrical quill 3 is supported via bearings 4a and 4b to be able to move in the left and right directions of the drawing. In this quill 3, a spindle 6 is rotatably supported via rolling bearings 5a and 5b. The spindle 6 is supported to be rotatable around the axis of the spindle 6, and it is also movable in reciprocation with the above-mentioned quill 3 in the axial direction of the housing 2. The end portion of the spindle 6 (shown in the right-hand of the drawing) penetrates the quill 3 and protruding outside from the end of the housing 2. A tap holder 7 is attached to the end portion of the spindle 6; moreover, a tap 8 is removably attached to the tap holder 7. The base of the spindle 6 (shown in the left-hand of the drawing) is protruding from the left side of the quill 3 in a housing 2.

The housing 2 is provided with a feed motor 9 composed of a servo motor for moving the spindle 6 in the axial

direction. This feed motor 9 is located on the inside surface near the end of the housing 2. The feed motor 9 is equipped with a stator 9a which is attached to the inside surface of the housing 2 and with a hollow rotor 9b which is rotatably attached to the inside surface of the stator 9a. The quill 3 is inserted into the hollow rotor 9. Moreover, plural cam followers 11 provided in the hollow rotor side are slidably engaged in a cam groove 10 which is spirally formed on the outer surface of the quill 3. In the above-mentioned constitution, the rotation of the feed motor 9 is converted into the movement in the axial direction of the quill 3, thereby the spindle 6 is reciprocated with the quill 3 in the axial direction by the reverse rotation of the feed motor 9. Moreover, the feed motor 9 is controlled to rotate by a synchronous control circuit 12 (shown in Fig. 2) as a synchronous control means.

On the other hand, a spindle motor 13 which is composed of a variable reluctance motor is installed in the housing 2 for rotating the spindle 6. The spindle motor 13 is located on the peripheral surface of the base portion of the spindle 6. The spindle motor 13 is equipped with a stator 13a attached to the inner surface of the housing 2 and a hollow rotor 13b which is rotatably attached to the inner surface of the rotor 13a. by means of bearings 14a and 14b. The base of the spindle 6 is formed as a spline 15, and long spline grooves 15a in the axial direction are formed on the outer surface of the spindle 6. The spline 15 is inserted into the hollow rotor 13b. Moreover, a spline nut 16 is engaged with

the hollow rotor 13b of the spindle motor 13, and the spline 15 is inserted into the spline nut 16 so as to engage with the spline grooves 15a. The spline nut 16 is relatively movable in the axial direction along the spline grooves 15a. Thus, the rotation of the spindle motor 13 is directly transmitted to the spindle 6 to rotate the spindle 6 regardless of the position in the axial direction of the spindle 6.

As shown in Fig. 2, the spindle motor 13 is equipped with a rotating position detector 19 which is composed of an encoder 17 for detecting the rotating position of the hollow rotor 13b and a counter 18 for calculating the output pulse from the encoder 17. The detection signal of the rotating position detector 19 is input into the aforementioned synchronous control circuit 12. Then, the spindle motor 13 is rotated and controlled by the synchronous control circuit 12 by means of a motor controller 20. The synchronous control circuit 12 synchronously controls the rotation of the spindle motor 13 and the reciprocation of the feed motor 9 such that the spindle 6 reciprocates at a predetermined ratio of the rotating speed corresponding to the pitch of the tap 8, etc. Thus, the spindle motor 13 rotates the spindle 6 while the feed motor synchronously reciprocates the spindle 6 in the axial direction.

In the above-mentioned constitution, when tapping is applied to a workpiece (not shown), the spindle motor 13 and the feed motor 9 are rotated, and the spindle 6 moves forward in the axial direction (to the right in Fig. 1) while it is

rotating. Thus, tapping is applied to the workpiece by the tap 8 attached to the end of the spindle 6. In this case, since the rotating speed and the advancing speed of the spindle 6 are controlled by the synchronous control circuit 12, the speed ratio can be optionally set. Accordingly, machining corresponding to the pitch of the tap 8 can be realized.

In this tapping unit 1, which adopts a variable reluctance motor to the spindle motor 13, the operational effects as set forth can be obtained.

As it is known, the variable reluctance motor does not include a permanent magnet, so that there is no need to consider the problem of demagnetization. Accordingly, it is possible to apply a large current to the spindle motor 13 to obtain a large driving torque. It is therefore possible to rotate the spindle 6 and the tap 8 with a high torque. Moreover, concerning a variable reluctance motor, it is known that a driving torque T is in nearly inverse proportion to the square of rotating speed N as shown by a curve A in Fig. 3. On the other hand, in a DC motor which is generally used for the spindle motor, the driving torque T and the rotating speed N has a relation shown by a straight line B in Fig. 3. In case of AC inductive motor, it is difficult to obtain large torque in comparison with the DC motor or the variable reluctance motor, so that it is required to enlarge the motor or to install a reducer. As described in the above, the variable reluctance motor which can obtain large driving torque in a low rotating speed is suitable to machining such

as tapping, and it is superior to the DC motor and the AC inductive motor in its characteristics.

The spindle motor 13 composed of a variable reluctance motor rotates the spindle 6 and the tap 8 with a large driving torque and thereby realizes tapping of large-diameter workpiece without making a large-size spindle motor 13.

In the present embodiment, the spindle motor utilizing a variable reluctance motor has no need to enlarge the scale of the spindle motor as discussed in the conventional spindle motor using a DC motor. Moreover, the spindle motor 13 of the present embodiment can obtain high torque output of the spindle 6 and the tap 8. As a result, tapping of large-diameter workpiece can be realized without producing a large-scale tapping unit 1.

While the invention has been practically shown and described with reference to a preferred embodiment, it will be understood by those skilled in the art that various other modifications may be made without departing from the spirit and scope of the invention. For example, a drill may be used as the tool of the machine tool instead of a tap.

CLAIMS

1. A device for machining a work piece, comprising:

a housing;

a spindle supported within the housing and defining a longitudinal axis such that the spindle is rotatable about and reciprocatable along that axis, the spindle being adapted to receive a tool at one end;

a feed motor mounted in the housing for reciprocating the spindle along the spindle axis;

a variable reluctance motor mounted in the housing for rotating the spindle about the spindle axis; and

control means for simultaneously controlling the feed motor and variable reluctance motor.

2. A device for machining a work piece, comprising:

a cylindrically shaped housing;

a spindle sleeve coaxially mounted within the housing such that the spindle sleeve may reciprocate along and rotate about an axis, a spiral cam groove being formed on the outer surface of the spindle sleeve;

a spindle having a first end coaxially mounted within the spindle sleeve such that the spindle may rotate about the axis relative to the spindle sleeve and reciprocate along the axis with the spindle sleeve, splines being formed on the first end of the spindle, the second end of the spindle being adapted to receive a tool;

a feed motor installed in the housing for reciprocating the spindle along the axis, the feed motor comprising:

a feed motor stator attached to the inside of the housing,

a feed motor rotor rotatably mounted adjacent the feed motor stator and comprising a hold in which the spindle sleeve is mounted, and

cam followers mounted on the surface of the hole in the feed motor rotor adapted to engage the cam groove such that, when the rotor rotates, the cam followers act on the cam groove to reciprocate the spindle sleeve and spindle along the axis;

a variable reluctance motor installed in the housing for rotating the spindle about the axis, the variable reluctance motor comprising

a reluctance motor stator attached to the inside of the housing;

a reluctance motor rotor rotatably mounted adjacent the reluctance motor stator, splines being formed on the reluctance motor rotor parallel to the axis for engaging the splines formed in the first end of the spindle such that rotation of the reluctance motor rotor causes the spindle to rotate about the axis while allowing the spindle to reciprocate along the axis; and

control means for substantially simultaneously controlling the feed motor and variable reluctance motor.

3. A device for machining a work piece, comprising:

a cylindrically shaped housing;

a spindle sleeve coaxially mounted within the housing such that the spindle sleeve may reciprocate along and rotate about an axis, a spiral cam groove being formed on the outer surface of the spindle sleeve;

a spindle having a first end coaxially mounted within the spindle sleeve such that the spindle may rotate about the axis relative to the spindle sleeve and reciprocate along the axis, where splines are formed on the first end of the spindle, the second end of the spindle being adapted to receive a tool;

a feed motor installed in the housing for reciprocating the spindle along the axis, the feed motor comprising

a feed motor stator attached to the inside of the